MEMORANDUM

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FROM: Gary Johnson, Ph.D.
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DATE: July 27, 2004

PROJECT: NY10132.000

SUBJECT: Measured and Calculated Magnetic Fields from a Split-Phase Transmission Line

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Magnetic field measurements were taken at two sites along a 115-kV transmission line operated by New York State Electric and Gas (NYSEG) near Sidney, New York on July 6, 2004. At one of the sites the transmission line was configured in a three-wire vertical delta configuration (Figure 1); at the second site the same transmission line was configured in a six-wire split-phase design with optimized phasing (reverse-phase) to reduce the possibility of interference to railroad signal circuits. The split-phase design is similar in appearance to a double circuit pole design.

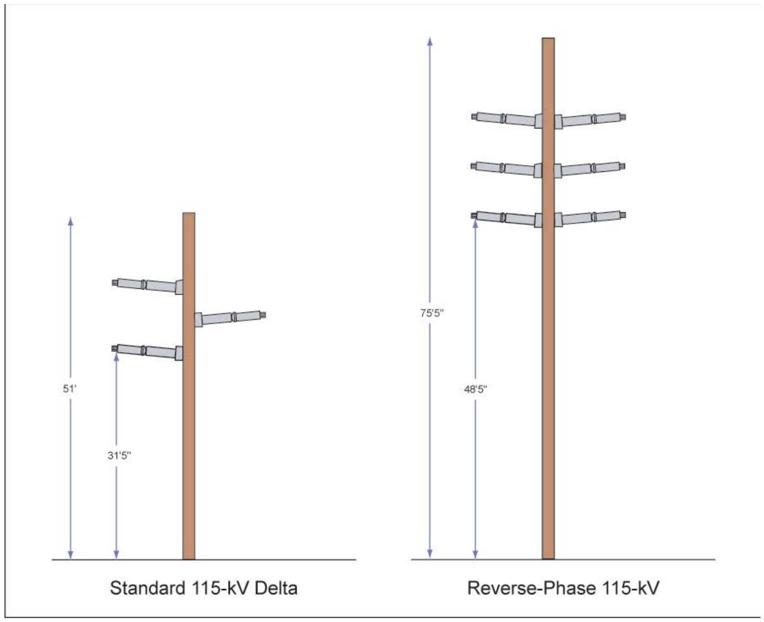

Figure 1. Examples of line configurations at the two sites along the 115-kV transmission line near Sidney, NY.

Magnetic field measurements were taken at a standard height of one meter (approximately 40 inches) with a three-axis Dexsil StAR magnetic field meter in accordance with the industry standard protocol for taking measurements near power lines (IEEE Std. 0644-1994). EMDEX Lite magnetic field meters set to record magnetic field measurements at four-second intervals were located at ground level 50 feet on either side of the lines to register any magnetic field changes related to variations in current flow during profile measurements. Magnetic field measurements were recorded in units of flux density (milligauss (mG) where 1 G = 1,000 mG). The manufacturer calibrated the meters by methods described in IEEE Std. 644-1994.

At the first site the transmission line was in a standard vertical delta configuration, shown in the left panel of Figure 2. A profile of the magnetic field was taken perpendicular to the line at midspan from –50 feet to +50 feet. The measured magnetic field profile is plotted in Figure 3.

Line heights and conductor separations were measured while on site. NYSEG provided the information on the line loading. This information was used to calculate the magnetic field from the line by the Bonneville Power Administration program (BPA, 1991). The calculated magnetic field during the period of the measured magnetic field is plotted in Figure 4. As can be seen in Figure 4, the measured magnetic fields and the calculated magnetic fields agree quite well.

Figure 2. 115-kV transmission line in delta configuration at Site 1.

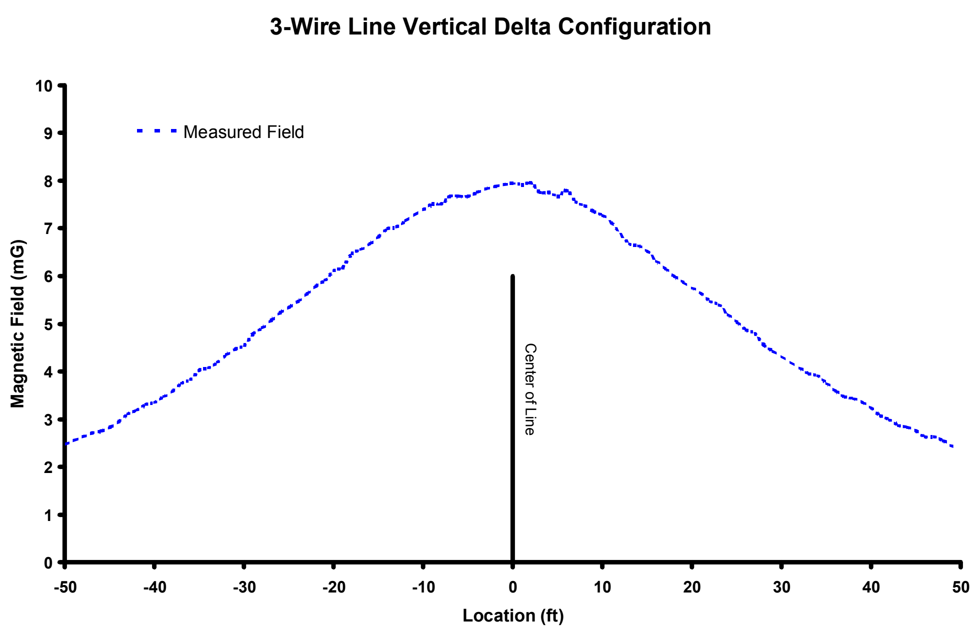

Figure 3. Magnetic field profile perpendicular to the delta configuration line at midspan.

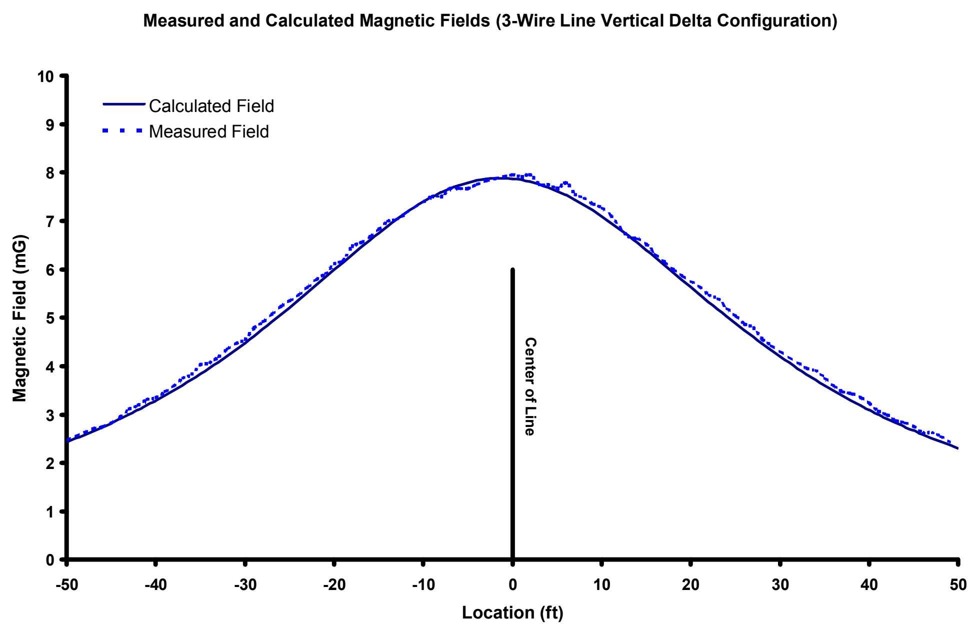

Figure 4. Calculated and measured magnetic field profile for the delta configuration line.

Measurements were also taken at Site 2 a few spans away from Site 1. Here, the transmission line was configured in a split-phase design with optimized phasing (reverse-phase) to minimize the magnetic fields. The line configuration is shown in Figure 5. For convenience, this design will hereafter be referred to as the split-phase design. The height of the split-phase line is approximately 20 feet higher than the delta configuration at Site 1.

Figure 5. Split-phase line with reverse phasing near Sidney, NY. The split-phase line is adjacent to a railroad.

A profile of the magnetic field was taken perpendicular to the line at midspan from –50 feet to +50 feet. The measured magnetic field profile is plotted in Figure 6. Due to the increased line height and the optimized split-phase line configuration, the measured magnetic fields are quite low and the jagged appearance of the measured profile reflects the 0.04 mG digital step size of the magnetic field meter. A railroad track located on one side of the line was elevated above the general terrain. This decreased the distance of the meter from the conductors as the profile crossed the railroad tracks (increase in field). The distance of the meter from the conductors increased as the profile extended further away from the line and beyond the railroad tracks because of the drop in terrain moving away from the railroad tracks (decrease in field). The position of the railroad track is indicated on the profile plot in Figure 6.

Line heights and conductor separations and line loading were used to calculate the magnetic field for the line. The calculated magnetic field during the period of the measurements is plotted with the measured magnetic field in Figure 7. The calculations assumed a flat terrain. Again, the calculated magnetic field agrees quite well with the measurements. Perturbations in the measurements due to variations in the terrain elevation can bee seen in Figure 7.

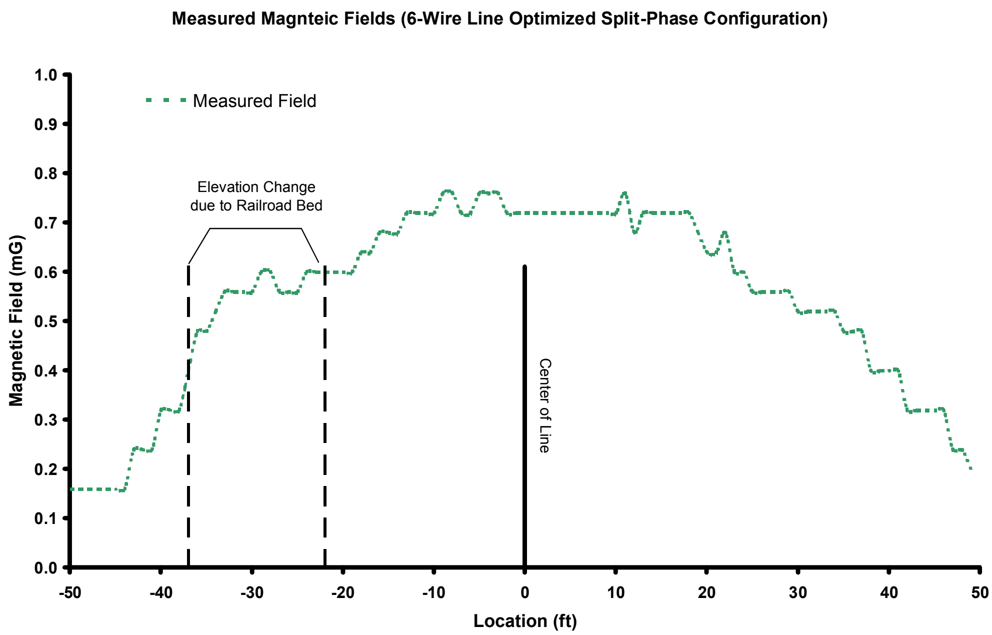

Figure 6. Magnetic field profile perpendicular to the split-phase configuration line at midspan.

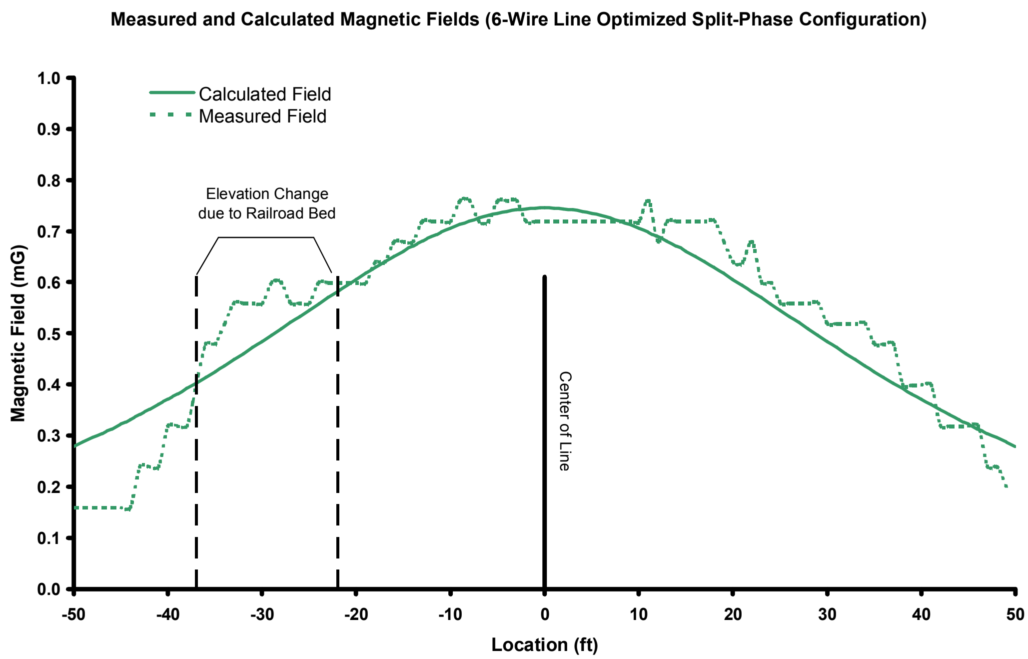

Figure 7. Calculated and measured magnetic field profiles for the split-phase configuration line.

A comparison of the measured magnetic field from the segment of line in the delta configuration versus the split-phase configuration for similar load conditions is plotted in Figure 8. As can be seen, the magnetic fields from the split-phase line segment are much lower than those at similar distances from the delta line configuration. This is due to both the increased height and design of the split-phase line compared to the delta line configuration.

In order to compare the optimized split-phase line to the delta line under similar conditions, the height of the 3-wire delta line was increased to the same height as the 6-wire split-phase line and the magnetic fields were calculated for the same line loading. The magnetic field comparison of the two line types for similar conditions is plotted in Figure 8. Figure 8 shows that the 6-wire optimized split-phase line configuration has much lower magnetic fields than the 3-wire delta line configurations for similar line height and currents.

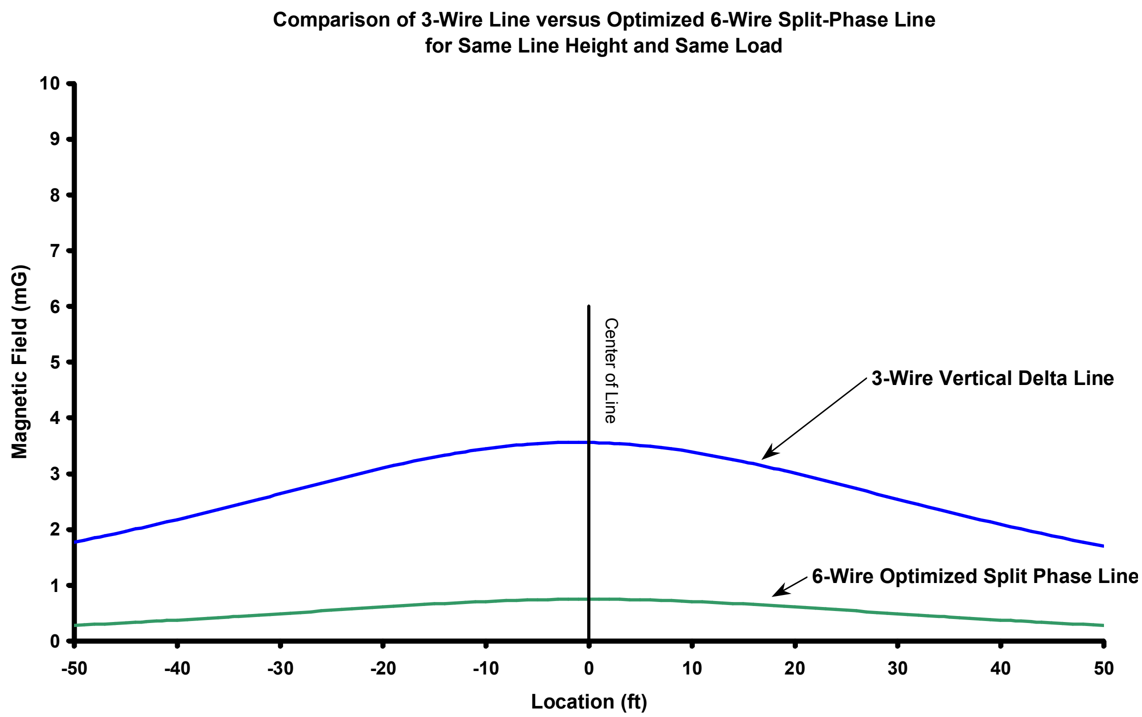

Figure 8. Comparison of the magnetic fields from the 6-wire optimized split phase line and 3-wire delta line for similar conditions.

Summary and Conclusion

A 115-kV transmission line in the NYSEG system has line sections configured in both delta and split-phase configurations. The phasing of the conductors on one side of the split-phase configuration is ABC (top to bottom); the phasing of conductors on the other side is CBA to achieve what is often called “reverse phasing.” Measurements of the magnetic field from this operating line demonstrate that the optimized split phase design achieves approximately a 10:1 reduction in the magnetic field. The lower field from the split-phase line is partially due to the higher height of the conductors. These measurements were shown to be consistent with the magnetic fields calculated by the Bonneville Power Administration program from input data on the line height, configuration, and load flow. Accounting for the increased height of the split-phase line results in a field reduction over the delta line for those of similar heights of 4.7:1 underneath the line, and 6.3:1 50 feet from the line. The reduction ratio for the optimized split-phase line over the delta line will continue to increase as the distance from the line increases.